

ANTIMICROBIAL GRIPS FOR SPORTS EQUIPMENTBackground of the InventionField of the Invention

[0001] In preferred aspects, the present invention relates to an antimicrobial grip for handles on devices that are subject to impact-related shock, changes in load-bearing, and/or slippage in the user's hands under damp conditions. More particularly, in preferred aspects, the present invention relates to a grip for handles on sports and exercise equipment, wherein the grip is adapted to inhibit microbial growth.

Description of the Related Art

[0002] Applicant has previously developed resilient grips which successfully reduce shock to the muscle and arm joints of the users of golf clubs, tennis racquets, racquetball racquets, baseball bats and other impact imparting devices such as hammers. See for example U.S. Patent Nos. 5,695,418, 5,797,813, and 5,857,929; incorporated herein in their entirety by reference. Such grips utilize a polyurethane layer bonded to a felt layer to define a strip which is spirally wrapped around the handle of a golf club, racquet or the like to conform to the external configuration of such handle.

[0003] Although previously resilient grips developed by Applicant afforded important advantages over prior art grips, particularly with respect to reducing impact-related shock and slippage due to accumulation of moisture, problems related to microbial growth have not been adequately addressed. Many species of bacteria, algae, yeast, mold and fungi are well-adapted to survive and even proliferate on conventional grips, particularly within perspiration and/or rain-moistened pores, folds and crevices. Microbial growth may be enhanced by storage in damp, dark racket sleeves or golf bags, etc. Microbial organisms can compromise the effectiveness of the grip and produce a slimy and/or slippery tactile effect and generate odor problems. Likewise, microbial contamination may reduce the useful life and/or discolor the grip. Perhaps most importantly, microbial contamination can cause health problems and contribute to the transmission of infectious agents.

[0004] One solution has been proposed in U.S. Application No. 09/810,392 filed on March 19, 2001 by Wang-Pin Pan and published as US 2002/0132876 (incorporated

herein in its entirety by reference) on September 19, 2002. It is suggested in this application that a mixed liquid comprising an aromatic tin-hydrocarbon ester can be either (1) spread onto a fabric, fastened to the handle portion of an exercise device, and coated with the handle grip rubber; or alternatively, (2) the finished rubber grip can be immersed in the mixed liquid, to produce a mildew-proof and antibacterial action. Unfortunately, the aromatic liquid is likely to dissipate quickly, wherein the desired effect will also diminish.

[0005] U.S. Pat. No. 5,960,578 (incorporated herein in its entirety by reference) discloses a shape-molded foam handle for fishing equipment comprising an elastomer, preferably a styrene block copolymer-based thermoplastic elastomer, which incorporates an inorganic germicidal agent, such as a silver-mineral complex (e.g., silver combined with a silica-alumina carrier, a zeolite carrier or a zirconium phosphate carrier). The molded thermoplastic germicidal handles disclosed in the '578 patent for fishing rods, nets, coolers, etc. fail to address the problems associated with impact-related shock on sports equipment grips and slippage due to accumulation of moisture.

[0006] Accordingly, there remains an urgent and unsatisfied need in the industry for antimicrobial handle grips for sports equipment, such as golf clubs, racquets, and/or exercise equipment, that exhibit long-lasting, non-toxic antibacterial, antifungal and antialgal actions, and protect users against shock to joints, muscles, tendons and bones due to impact and/or load shifting, and slippage due to moisture.

Summary of the Invention

[0007] An antimicrobial grip is disclosed in accordance with an embodiment of the present invention. The grip comprises an elongated strip comprising an elastomer layer bonded to a textile layer, wherein the elastomer layer further comprises an inorganic antimicrobial agent.

[0008] Preferably, the elastomer layer comprises polyurethane. More preferably, the polyurethane has a plurality of closed pores that extend vertically in a direction normal to a longitudinal axis of the elongated strip.

[0009] The textile layer preferably comprises felt and an adhesive layer and a protective quick-release tape, such that upon release of the tape, the elongated strip can be adhered to a handle.

[0010] The inorganic antimicrobial agent comprises an antimicrobial metal, selected from the group consisting of silver, copper, zinc, tin, mercury, lead, iron, cobalt, nickel, manganese, arsenic, antimony, bismuth, barium, cadmium and chromium. Preferably, the antimicrobial metal is silver or zinc. More preferably, the antimicrobial metal is silver.

[0011] The antimicrobial agent further comprises a porous mineral-based carrier. In preferred embodiments, the porous mineral-based carrier is selected from the group consisting of a silica-alumina carrier, a zeolite carrier, or a zirconium phosphate carrier. More preferably, the mineral based carrier is a silica-alumina carrier. Most preferably, the silica-alumina carrier is montmorillonite, having a chemical formula: Na 0.7 Al 3.3 Mg 0.7 Si 8 O 20 (OH)4 · nH₂O.

[0012] In preferred embodiments of the grip of the present invention, the inorganic antimicrobial agent is present at a concentration by weight in a range of about 0.1% to 20%. More preferably, the concentration by weight of the inorganic antimicrobial agent is in a range of about 1% to 10%. Most preferably, the concentration by weight of said inorganic antimicrobial agent is about 2%.

[0013] In accordance with another aspect of the present invention, a golf club is disclosed. The golf club comprises an antimicrobial grip comprising a layer of polyurethane bonded to a layer of felt. The layers of polyurethane and felt are configured so as to reduce impact-related shock. The polyurethane layer further comprises a silver-based inorganic antimicrobial agent dispersed therein. Preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 1% to 15% by weight. More preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 2% by weight.

[0014] In accordance with another aspect of the present invention, a racquet is disclosed. The racquet comprises an antimicrobial grip comprising a layer of polyurethane bonded to a layer of felt. The layers of polyurethane and felt are configured so as to reduce impact-related shock. The polyurethane layer further comprises a silver-based inorganic antimicrobial agent dispersed therein. Preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 1% to 15% by

weight. More preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 2% by weight.

[0015] In accordance with another aspect of the present invention, an exercise device is disclosed. The exercise device comprises an antimicrobial grip comprising a layer of polyurethane bonded to a layer of felt. The layers of polyurethane and felt are configured so as to reduce impact-related shock. The polyurethane layer further comprises a silver-based inorganic antimicrobial agent dispersed therein. Preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 1% to 15% by weight. More preferably, the silver-based inorganic antimicrobial agent comprises montmorillonite containing silver at a concentration of about 2% by weight.

Brief Description of the Drawings

[0016] FIG. 1 is a broken perspective view of a shock-absorbing antimicrobial grip in accordance with a preferred embodiment of the present invention.

[0017] FIG. 2 is a broken view of the underside of an embodiment of the antimicrobial grip showing a quick-release tape covering an adhesive layer.

[0018] FIG. 3 is a sectional view taken in enlarged scale along line 3—3 for FIG. 1.

[0019] FIG. 4 is a further enlarged view of the encircled area designated 4 in FIG. 3.

[0020] FIG. 5 is a perspective view of a golf club provided with an antimicrobial grip in accordance with one preferred embodiment of the present invention.

[0021] FIG. 6 is a perspective view showing an antimicrobial grip in accordance with one preferred embodiment of the present invention being applied to a tennis racket.

[0022] FIG. 7 is a perspective view showing an antimicrobial grip in accordance with one preferred embodiment of the present invention on a tennis racket.

Detailed Description of the Preferred Embodiment

[0023] In accordance with one embodiment of the present invention, a handle grip is disclosed having an inorganic antimicrobial agent incorporated therein. Antimicrobial is used herein to denote any action which inhibits the proliferation, growth and/or survival of

any microscopic and/or macroscopic organisms, including bacteria, viruses, parasites, mold, mildew, fungi, algae, etc. In preferred embodiments, the handle grip is adapted for use with various sports equipment that may support the growth and/or survival of microbial organisms, such as for example, handle grips that are moistened in routine use by exposure to rain and/or perspiration. More preferably, the grips of the present invention are designed to prevent microbial growth on handles of equipment used in impact-related sports, such as for example, golf clubs, racquet ball racquets, tennis racquets, and squash racquets, etc. In another preferred embodiment, the present grips are designed for use on impact-imparting tools, such as hammers and axes. In another preferred embodiment, the present grips are designed for use on home and gym exercise equipment, particularly on equipment, such as weight machines, where cushioning and protection for the users' hands, feet, joints, tendons, muscles and bones are desired. Although modern exercise equipment is now designed to reduce impact-related shock and sudden changes in load-bearing, injuries from these stresses continue to be a significant problem for gym users, particularly novice users unaccustomed to the equipment. Moreover, communication of pathogenic microbes among shared users of exercise equipment in gyms and sports clubs is a prevalent problem, which is presently poorly addressed and even exacerbated by voluntary wipe-down etiquette using perspiration-moistened towels.

[0024] Antimicrobial Agents – Although numerous organic compounds are known to possess potent contact-mediated antimicrobial actions (e.g., alcohol), such compounds are poorly suited for long-term protection and for incorporation into the grip material. In accordance with preferred aspects of the present invention, inorganic materials are used as the antimicrobial agent, such as metals having antimicrobial properties. Silver, copper, zinc, tin, mercury, lead, iron, cobalt, nickel, manganese, arsenic, antimony, bismuth, barium, cadmium and chromium have been known for a long time as metals which exhibit antifungal, antialgal and antibacterial activities (hereinafter referred to as “antimicrobial metals”). In particular, silver has been widely used in the form of aqueous silver nitrate solution as bactericidal and/or disinfectant solutions. However, some of the above-mentioned antimicrobial metals have been found to be toxic for humans. Furthermore, some of the toxic metals also have various practical and regulatory limitations in methods of use, storage and disposal. Consequently, their use as antimicrobial agents has been limited.

[0025] Recently, Applicant has found that relatively small concentrations of the antimicrobial metal, silver, particularly when combined with a non-toxic porous mineral carrier, is sufficient to provide the desired antimicrobial actions without risk of toxic effects for humans. As compared with organic antimicrobial agents, the inorganic antimicrobial agents are higher in safety, exhibit prolonged antimicrobial effect and superior heat resistance.

[0026] Powdered composite materials, comprising an antimicrobial metal in combination with a porous mineral-based carrier (hereinafter "inorganic antimicrobial agent") are preferred in accordance with the present invention. Silver-based inorganic antimicrobial agents are most preferred. Examples of such silver-based inorganic antimicrobial agents include silver combined with a silica-alumina carrier, a zeolite carrier, or a zirconium phosphate carrier (see e.g., U.S. Pat. No. 5,960,578; incorporated in its entirety herein by reference). These inorganic antimicrobial agents cause less skin irritation and offer much improved longevity, when compared with typical volatile organic agents. In addition, silver-based inorganic antimicrobial agents rarely cause metal allergies when compared with inorganic germicidal agents containing metals other than silver.

[0027] Some silver-based inorganic antimicrobial agents are commercially available, such as for example, BACTEKIRANI (Kanebo Co.), which is a complex of silver and zeolite, and NOVALON, (Toa Gosei Co.), which is a complex of silver and zirconium. One particularly preferred silver-based inorganic antimicrobial agent in accordance with the present invention is "Nanometers Layeric Silver System Inorganic Antibacterial Powder" (Beijing STR Inc., Ltd.), which is a complex of silver (2% by weight) and montmorillonite. The chemical formula of montmorillonite is $\text{Na}_{0.7}\text{Al}_{3.3}\text{Mg}_{0.7}\text{Si}_8\text{O}_{20}(\text{OH})_4 \cdot n\text{H}_2\text{O}$.

[0028] The inorganic antimicrobial agent is preferably dispersed with the elastomer-forming solution (e.g., preferably polyester or polyether for formation of polyurethane) prior to polymerization. The concentration (by weight) of the antimicrobial agent in the elastomeric formulation is preferably in the range of about 0.1% to 20%. More preferably, the concentration ranges from about 1% to about 10% by weight. Most preferably, the concentration is about 2% by weight.

[0029] Grip Construction – With reference to FIG. 1, a preferred grip embodying the present invention utilizes an elongated strip G formed from a layer of an open-pored

textile 12, such as felt, coated with a layer of an elastomeric material 16, for example a smooth layer of closed pore polyurethane as detailed in U.S. Pat. Nos. 5,695,418, 5,797,813, and 5,857,929 (incorporated herein in their entirety by reference). In preferred embodiments, the inorganic antimicrobial agent is evenly dispersed throughout the elastomeric material. The elongated strip G can be spirally wrapped about the handle of the sports equipment. Although the various embodiments of the antimicrobial grip set forth below are described as comprising a polyurethane layer bonded to a felt layer, it is understood that other elastomers besides polyurethane and other textile (or non-textile) open-pore layers besides felt, which are known in the art, can be used in accordance with various aspects of the present invention. For example, in some embodiments, the textile layer may be replaced by a water-excluding polymeric material, such as a layer of ethylene vinyl acetate (EVA), as detailed in co-pending U.S. Appl. No. 09/929,414; the entire disclosure of which is incorporated herein by reference thereto.

[0030] With reference to FIG's. 2-4, the grip preferably includes an open-pored textile layer 12 (e.g., preferably felt) having an inner or bottom surface 14 which is designed to be adhered directly to the handle or alternatively to a resilient sleeve attached to the upper portion of the handle. An elastomer layer 16, preferably a closed pore polyurethane layer, is bonded to the outer surface of the felt layer 12 as described below. The bonded-together elastomer and felt layers are preferably configured as unitary strip.

[0031] More particularly, with reference to FIG. 2-4, the underside 14 of the felt 12 is provided with a conventional adhesive layer 30 which is originally covered with a protective quick-release tape 32. To apply the grip to the handle, the protective tape 32 is stripped off the adhesive 30, as illustrated in FIG. 2 and the unitary strip is tightly wound around the handle as is well-known in the art. The felt layer 12 of the strip is directly bonded to the polyurethane layer 16. Preferably, closed pores 22, in the polyurethane layer extend vertically, i.e. generally normal to the longitudinal axis of the strip and handle when the grip has been affixed to the handle, as illustrated in FIG's. 3 and 4.

[0032] The purpose of the layer of polyurethane 16 is primarily to provide a cushioning effect for the handle grip, which protects the user against impact-related shock and/or shifts in load-bearing. Such cushioning effect is enhanced by compression of the vertically aligned pores 22 in the polyurethane layer. It has been found that such

compression greatly inhibits the shock applied by a club or racquet to the user's arm and hand created when the ball hits the club or racquet. The polyurethane layer 16 also provides tackiness so as to inhibit the user's hand from slippage. The felt layer 12 provides strength to the polyurethane layer 16 and also serves as a means for attaching the unitary bonded-together strip of polyurethane and felt to the handle.

[0033] As illustrated in FIG's 5-7, the antimicrobial grip G may be applied as a spirally wound strip S to the shaft 14 of a golf club (FIG. 5), or a racquet R (FIG's 6-7). In preferred embodiments, the polyurethane and felt layers may be formed with vertically extending perforations as illustrated in FIG's 6 and 7. The perforations are adapted to improve the resistance to slippage by enhancing the absorption rate of perspiration from a user's hand. Such pores or perforations have also been found to improve the cushioning effect of the grip by providing a controlled restriction of air escaping from within the open pores of the felt layer when the grip is grasped.

[0034] Applications and health-related benefits – As discussed above, the invention is not limited to clubs and racquets designed to impact a ball. Indeed, the antimicrobial grip in accordance with preferred embodiments of the present invention can be applied to any handle or shaft in which protection is desired from *inter alia*: (1) the detrimental and health-related effects of microbial growth; (2) impact-related shock; (3) changes in load-bearing; and (4) slippage. Detrimental effects of microbial growth on grip performance and useful life include without limitation, discoloration, odor, slimy and/or slippery tactile effect, deterioration of grip materials, de-lamination of the elastomer and textile layers, reduced adhesion to the handle shaft, etc.

[0035] Health-related effects include without limitation transmission of communicable disease pathogens (including bacteria, viruses, mold, fungi, yeast, parasites, etc.) through direct skin contact with the grips of shared sports equipment. According to <http://www.bodybuilding.com/fun/huston5.htm>, “[s]weat is a good way to transmit Staph bacteria and other communicable diseases.” Indeed, health officials in Los Angeles have noted an alarming increase in the “outbreak of antibiotic-resistant skin infection seen in groups such as athletes... who share things like gym equipment and towels.” <http://www.siliconvalley.com/mld/siliconvalley/news/5051309.htm>. While gym suppliers are selling disinfectants designed to kill Staph, Salmonella, HIV-1, Herpes Simplex Type 2,

and Athlete's foot fungus (http://www.gympart.com/trainer/10_lockerroom_pg32.pdf); such disinfectant treatment does not address the problem of communication of microbes between consecutive users during a typical day—wherein disinfecting may occur infrequently, for example, when the gym is closed at night.

[0036] More particularly, <http://www.beingalive.org/pdf/nl052003.pdf> states that:

[0037] "Staph is bacteria commonly found on human skin. Sometimes it does not cause any problems; sometimes it causes minor infections, such as pimples or boils. The skin infections often begin with an injury to the skin where the Staph enters the skin weakened by the injury and develops into an infection. Symptoms of a Staph infection include redness, warmth, and swelling, tenderness of the skin, and boils or blisters. Staph can rub off the skin of an infected person onto the skin of another person during prolonged skin to skin contact between them, or it can come off the infected skin of a person onto commonly shared objects or surfaces, and get into the skin of the person who uses it next... Examples of objects that are commonly shared are... athletic equipment used in a gym."

[0038] Thus, the antimicrobial grips in accordance with preferred embodiments of the present invention meet a long-felt and important need in the sports equipment area with respect to reducing communication of microbial pathogens.

[0039] Accordingly, the antimicrobial grips are applicable for use on any sports equipment, like golf clubs and tennis racquets, impact-transferring handles of tools, like hammers and axes, and impact-transferring and/or load-bearing handles of gym equipment, like weight machines, rowing machines, elliptical trainers, stationary bikes, etc.

[0040] Manufacturing Processes – The elastomer (preferably polyurethane) layer may be formed in a conventional manner by coating one side of a felt strip (or other open pore textile or non-textile material) with a solution comprising the elastomeric formulation (preferably polyurethane, e.g. polyester or polyether) dissolved in a suitable solvent, preferably dimethyl formamide (DMF), and the antimicrobial agent. The concentration (by weight) of the antimicrobial agent in the elastomeric formulation is preferably in the range of about 0.1% to 20%. More preferably, the concentration ranges from about 1% to about 10% by weight. Most preferably, the concentration is about 2% by weight. The coated strip is immersed in consecutive water bath(s) to displace the DMF with water, causing the urethanes to coagulate. The strip is further treated by application of pressure and heat to displace the water with air.

[0041] In one preferred process mode, an accelerator of polyurethane coagulation, e.g., Assistor SD-7 (Lidye Chemical Co., Ltd.), is added to the coating solution at a concentration of about 0.1 to about 5%, more preferably about 0.5% to 2%, and most preferably, about 1%. In this manner, the pores will extend perpendicularly relative to the longitudinal axis of the strip, while the underside of the polyurethane layer is bonded to the outer surface of the felt strip. In one preferred embodiment, the ratio of the thickness of the polyurethane layer to the felt layer is at least about 0.18.

[0042] Application to handles – In preferred embodiments, the elongated strip is applied directly to the handle by peeling off a quick-release tape covering an adhesive on the underside of the felt layer, as illustrated in FIG's 2-4. The strip is then spirally wound around the handle shaft starting with the butt or top end of the handle, as shown in FIG. 6. After the strip has been completely wound about the shaft, its lower end may be secured in place by finishing tape and/or a conventional resilient ferrule to prevent unraveling of the lower portion of the strip relative to the handle.

[0043] Alternatively, the strip may be spirally wrapped around a resilient rubber-like sleeve made of a synthetic plastic foam or rubber. The sleeve is slipped over the handle portion of the sports equipment. The elongated strip is spirally wrapped about sleeve and finished with tape or the like. It should be noted that rather than wrapping the strip around the sleeve after the sleeve has been applied to the handle, the sleeve may be mounted on a tapered mandrel and the strip spirally wrapped about the sleeve. The resulting assembly of sleeve and strip may be marketed as a replacement grip or as original equipment installed on the sports equipment. If desired, the grip receiving portion of the shaft or handle may be expanded radially at a greater angle than the main portion of the shaft to enhance the grasp of the grip by a user.

WORKING EXAMPLES

[0044] Unitary strips of grip material were made as described above, with and without 2% by weight Nanometers Layeric Silver System Inorganic Antibacterial Powder (purchased from Beijing STR Inc., Ltd.), containing 2% by weight silver. The powdered inorganic antimicrobial agent was evenly dispersed in a solution of polyurethane (MP-812; Lidye Chemical Co., Ltd.) in 70% dimethyl formamide (DMF) containing 1% by weight of the coagulation enhancer (SD-7; Lidye Chemical Co., Ltd.). The elastomer dispersion

containing the inorganic antimicrobial agent was layered onto a felt strip, which was then washed in four consecutive water baths at 40-70° C, to remove DMF and induce coagulation of the urethanes. Water was removed by heating to 90° C.

[0045] Portions of the control (no antimicrobial agent) and treated grips were then tested for growth of the bacteria *Escherichia coli* (*E.coli*), in accordance with standard published procedures (GB15979, GB8629-88, The Institute for Antibacteria Technology (3rd Edition); Book I, FZZ/T0102, pg. 1-92, Japan JIS, AATCC1000 Standard of Antibacteria). Control and treated samples of grip material were inoculated with *E. coli* by streaking a 0.2ml volume of inoculum onto the surface of the grip samples at 25-26° C. After incubating for 4 hrs, bacteria were collected from the grips by washed with 5 ml PBS. The wash was cultured on agar for 8 hrs and bacterial counts were quantified in colony-forming units (cfu/ml). The results are shown in TABLE 1.

TABLE 1

SAMPLE	0 hour	4 hours	4 hours	4 hours
	Bacterial Count (cfu/ml)	Bacterial Count (cfu/ml)	Percent Inhibition (%)	Difference in Percent Inhibition (%)
Control	19600	18700	4.59	—
+ Antimicrobial Agent	19600	900	95.41	90.82

[0046] The antimicrobial grip material made in accordance with a preferred embodiment of the present invention killed approximately 95.41% of the *E. coli* bacteria applied to the grip after 4 hours at 25-26° C. In contrast, the level of bacteria surviving on the untreated, control grip was essentially the same as the starting (0 hour) inoculum. Clearly, the incorporation of 2% by weight of the inorganic antimicrobial agent within the outer polyurethane layer of the grip material resulted in a handle grip which effectively eliminates bacteria from the grip surface.

[0047] In follow-up testing, Applicant is applying other microbial strains, including other bacteria, viruses, fungi, molds, and parasites to the control and antimicrobial grips. In variations to the above outlined experiments to assess the spectrum of bacteria and other microbes against which Applicant's grips are effective in inhibiting growth, proliferation and survival. The concentrations of different antimicrobial agents (e.g., silver and zinc based mineral formulations) will be varied in the range of 0.1% to 20% by weight. Positive germicidal effects are expected for a broad spectrum of microbes. Further, at least the silver-containing (and probably the zinc-containing) formulations also are expected to produce positive antimicrobial effects of greater than about 90% inhibition of colony growth and survival. Positive antimicrobial effects are seen at concentrations of the inorganic antimicrobial agents between 1% and 10% by weight. Optimal germicidal effects are predicted at about 2% by weight of the inorganic antimicrobial agents, based on Applicant's results with *E. coli*. Results of the prophetic examples are supported by Applicant's working example with *E. coli* as well as the extensive literature on the antimicrobial actions of silver (See e.g., Muller G, Winkler Y, Kramer A. (2003) Antibacterial activity and endotoxin-binding capacity of Actisorb Silver 220. *J. Hosp. Infect.* 53(3): 211-4; Karlov AV, Khlusov IA, Pontak VA, Ignatov VP, Ivin MA, Zinatulina SY (2002) Adhesion of *Staphylococcus aureus* to implants with different physicochemical characteristics. *Bull Exp Biol Med.* 134(3): 277-80; Bellantone M, Williams HD, Hench LL. (2002) Broad-spectrum bactericidal activity of Ag₂O-doped bioactive glass. *Antimicrob Agents Chemother.* 46(6): 1940-5; Lansdown AB (2002) Silver. I: Its antibacterial properties and mechanism of action. *J. Wound Care.* 11(4): 125-30).

[0048] Further, silver is reported <http://colloidalsilver.hypermart.net/silver/faq>, as a "powerful germicidal... that it is non-toxic to the human body, but lethal to over 650 disease-causing bacteria, viruses, fungi, parasites, and molds; while conventional pharmaceutical antibiotics are typically effective against only 6 or 7 types of bacteria.

[0049] According to Davies and Etris (1996), silver provides antimicrobial actions via three distinct mechanisms of action: (1) catalytic oxidation, (2) reaction with cell membranes, and (3) binding to microbial DNA to prevent transcription. More particularly, atomic(nascent) oxygen absorbed onto the surface of silver ions will readily react with the sulfhydryl (-S-H) groups surrounding the surface of bacteria or viruses to remove the

hydrogen atoms (as water), causing the sulfur atoms to form an R-S-S-R bond; blocking respiration and causing the bacteria to expire. There is evidence that silver ions attach to membrane surface radicals of bacteria, impairing cell respiration and blocking its energy transfer system. The DNA of *Pseudomonas aeruginosa*, a tenacious bacteria that is difficult to treat, has been shown to take up silver. While it remains unclear exactly how the silver binds to the DNA without destroying the hydrogen bonds holding the lattice together, it nevertheless prevents the DNA from *unwinding*, an essential step for cellular replication to occur (Fox and Modak; cited in <http://colloidalsilver.hypermart.net/silver/faq.html>).

[0050] In another study, reported in <http://www.dietsexercise.com/anthrax-colloidal-silver.htm>, silver was shown to be effective in treating ear infections, yeast infection (*Candida*), viral infection (common cold), *E. coli* infection, intestinal infection, sinus infection, HIV infection, Lyme disease, Herpes (HSV-2) viral infection, Anthrax infection, and food poisoning.

[0051] Based on Applicant's study results and the literature reports with regard to the antimicrobial actions of silver, results of the provided prophetic microbe spectrum analysis, antimicrobial agent testing, and concentration experiments are likely to be consistent with the predicted outcomes.

[0052] While a particular form of the invention has been illustrated and described, it will also be apparent to those skilled in the art that various modifications can be made without departing from the spirit and scope of the invention. Accordingly, it is not intended that the invention be limited except by the appended claims.